

**In the Claims**

Claims 46-51 are canceled without prejudice.

Claims 1-5, 10, and 19-45 and 52-63 remain in the application for consideration and are listed below:

1. (ORIGINAL) A facial expression transformation method comprising:

defining a code book containing data defining a first set of facial expressions of a first person;

providing data defining a second set of facial expressions, the second set of facial expressions providing a training set of expressions of a second person who is different from the first person;

deriving a transformation function from the training set of expressions and corresponding expressions from the first set of expressions; and

applying the transformation function to the first set of expressions to provide a synthetic set of expressions.

2. (ORIGINAL) The method of claim 1, wherein the training set of expressions contains fewer expressions than the code book.

3. (ORIGINAL) The method of claim 1, wherein the transformation function compensates for differences in the size and shape of the faces of the first and second persons.

4. (ORIGINAL) The method of claim 1, wherein said deriving of the transformation function comprises computing a linear transformation from one set of expressions to another.

5. (ORIGINAL) The method of claim 1, wherein the deriving of the transformation function comprises:

representing each expression as a  $3m$ -vector that contains  $x$ ,  $y$ ,  $z$  displacements at  $m$  standard sample positions; and

computing a set of linear predictors  $a_j$ , one for each coordinate of  $g_a$ , given a set of  $n$  expression vectors for a face to be transformed,  $g_{a1...n}$ , and a corresponding set of vectors for a target face,  $g_{b1...n}$ , by solving  $3m$  linear least squares systems of the following form:

$$a_j \cdot g_{a1} = g_{b1}[j], i = 1..n$$

6.-9. (CANCELED).

10. (ORIGINAL) The method of claim 1, wherein said providing data defining a second set of facial expressions comprises:

illuminating the second person's face with illumination; and  
contemporaneously capturing structure data describing the face's structure and reflectance data describing reflectance properties of the face from the illumination.

11.-18 (CANCELED).

1           **19. (ORIGINAL)** One or more computer-readable media having  
2 computer-readable instructions thereon which, when executed by a computer,  
3 cause the computer to:

4           operate on a training set of expressions from one person and corresponding  
5 expressions from a code book of another person to compute a linear  
6 transformation function from the training set and their corresponding expressions;  
7 and

8           apply the transformation function to a plurality of expressions from the  
9 code book to provide a synthetic set of expressions.

10  
11           **20. (ORIGINAL)** The computer-readable media of claim 19, wherein  
12 the instructions cause the computer to use the synthetic set of expressions to  
13 transform expressions from the one person into expressions of the other person.

14  
15           **21. (ORIGINAL)** The computer-readable media of claim 20, wherein  
16 the instructions cause the computer to transform expressions from the one person  
17 that are different from those expressions comprising the code book expressions.

18  
19           **22. (ORIGINAL)** The computer-readable media of claim 20, wherein  
20 the instructions cause the computer to transform expressions by transmitting at  
21 least one index of a synthetic expression to a receiver that can reconstruct the  
22 expression.

23  
24           **23. (ORIGINAL)** The computer-readable media of claim 20, wherein  
25 the instructions cause the computer to transform facial expressions.

1  
2       **24. (ORIGINAL)** A facial expression transformation system  
3 comprising:

4       a code book embodied on a computer-readable medium, the code book  
5 containing data defining a first set of facial expressions of a first person;

6       data embodied on a computer-readable medium, the data defining a second  
7 set of facial expressions, the second set of facial expressions providing a training  
8 set of expressions of a second person who is different from the first person; and

9       a transformation processor configured to derive a transformation function  
10 from the training set of expressions and corresponding expressions from the first  
11 set of expressions.

12  
13       **25. (ORIGINAL)** The expression transformation system of claim 24,  
14 wherein the transformation processor comprises a linear transformation processor.

15  
16       **26. (ORIGINAL)** The expression transformation system of claim 24  
17 further comprising a synthetic set of expressions embodied on a computer-  
18 readable medium, the synthetic set of expressions being derived by applying the  
19 transformation function to the code book expressions.

20  
21       **27. (ORIGINAL)** The expression transformation system of claim 24,  
22 wherein the transformation function compensates for differences in the size and  
23 shape of the faces of the first and second persons.

28. (ORIGINAL) The expression transformation system of claim 24,  
 wherein the transformation processor derives the transformation function by:  
 representing each expression as a  $3m$ -vector that contains  $x$ ,  $y$ ,  $z$   
 displacements at  $m$  standard sample positions; and  
 computing a set of linear predictors  $a_j$ , one for each coordinate of  $g_a$ , given  
 a set of  $n$  expression vectors for a face to be transformed,  $g_{a1...n}$ , and a  
 corresponding set of vectors for a target face,  $g_{b1...n}$ , by solving  $3m$  linear least  
 squares systems of the following form:

$$a_j \cdot g_{ai} = g_{bi}[j], i = 1...n$$

29. (ORIGINAL) A facial expression transformation system  
 comprising:

- a transmitter comprising:
  - a facial illumination system that is configured to provide multiple different  
 light sources at the same time for illuminating a subject's face;
  - a data-capturing system configured to capture both structure data and  
 reflectance data from the subject's face when illuminated by the facial  
 illumination system; and
  - a first code book of synthetic expressions that have been synthesized by:  
 receiving a training set of expressions provided by the subject;  
 computing a transformation function using the training set of expressions  
 and corresponding unsynthesized code book expressions; and  
 applying the transformation function to all of the expressions in the code  
 book; and
  - a receiver communicatively linked with the transmitter and comprising:

1 a reconstruction module for reconstructing facial images; and  
2 a second code book containing the same synthetic expressions as the first  
3 code book; and  
4 the transmitter being configured to:  
5 capture additional expressions of the subject;  
6 search the first code book for a corresponding or near matching expression;  
7 and  
8 transmit an index of a corresponding or matching code book expression to  
9 the receiver for facial image reconstruction by the reconstruction module.  
10

11 **30. (ORIGINAL)** The expression transformation system of claim 29,  
12 wherein the illumination system comprises at least one polarized light source.  
13

14 **31. (ORIGINAL)** The expression transformation system of claim 29,  
15 wherein the illumination system comprises multiple polarized light sources.  
16

17 **32. (ORIGINAL)** The expression transformation system of claim 29,  
18 wherein the illumination system comprises a patterned light source configured to  
19 project a pattern onto the subject's face.  
20

21 **33. (ORIGINAL)** The expression transformation system of claim 29,  
22 wherein the illumination system comprises an infrared patterned light source  
23 configured to project a pattern onto the subject's face.  
24  
25

1       **34. (ORIGINAL)** The expression transformation system of claim 29,  
2 wherein the different light sources are all infrared light sources.

3  
4       **35. (ORIGINAL)** A method of animating facial features comprising:  
5 defining a subdivision surface that approximates geometry of a plurality of  
6 different faces; and  
7 fitting the same subdivision surface to each of the plurality of faces.

8  
9       **36. (ORIGINAL)** The method of claim 35, wherein said defining  
10 comprises defining the subdivision surface with a coarse mesh structure.

11  
12       **37. (ORIGINAL)** The method of claim 36, wherein the coarse mesh  
13 structure comprises a triangular mesh.

14  
15       **38. (ORIGINAL)** The method of claim 35, wherein said fitting  
16 comprises performing a continuous optimization operation over vertex positions of  
17 the subdivision surface.

18  
19       **39. (ORIGINAL)** The method of claim 35, wherein said fitting  
20 comprises fitting the subdivision surface to the faces without altering the  
21 connectivity of a mesh that defines the subdivision surface.

22  
23       **40. (ORIGINAL)** The method of claim 35, wherein said fitting  
24 comprises minimizing a smoothing functional associated with a mesh that defines  
25 the subdivision surface.

1  
2       **41. (ORIGINAL)** The method of claim 35, wherein said fitting  
3 comprises selecting one or more constraints associated with a mesh that defines  
4 the subdivision surface and fitting those constraints directly to corresponding  
5 points on the faces.

6  
7       **42. (ORIGINAL)** The method of claim 41, wherein the constraints are  
8 associated with one of the eyes, nose and mouth.

9  
10       **43. (ORIGINAL)** The method of claim 35, wherein said fitting  
11 comprises minimizing a functional that includes terms for distance, smoothness,  
12 and constraints.

13  
14       **44. (ORIGINAL)** The method of claim 35, wherein said fitting  
15 comprises solving a sequence of linear least-squares problems.

16  
17       **45. (ORIGINAL)** One or more computer-readable media having  
18 computer-readable instructions thereon which, when executed by one or more  
19 computers, cause the one or more computers to implement the method of claim 35.

20  
21       **46.-51. (CANCELED)**

22  
23       **52. (PREVIOUSLY PRESENTED)** A facial expression transformation  
24 method comprising:  
25



1 defining a code book containing data defining a first set of facial  
2 expressions of a first person;

3 providing data defining a second set of facial expressions, the second set of  
4 facial expressions providing a training set of expressions of a second person who  
5 is different from the first person;

6 deriving a transformation function from the training set of expressions and  
7 corresponding expressions from the first set of expressions, wherein the deriving  
8 of the transformation function comprises:

9 representing each expression as a  $3m$ -vector that contains  $x$ ,  $y$ ,  $z$   
10 displacements at  $m$  standard sample positions; and

11 computing a set of linear predictors  $a_j$ , one for each coordinate of  $g_a$ ,  
12 given a set of  $n$  expression vectors for a face to be transformed,  $g_{a1...n}$ , and a  
13 corresponding set of vectors for a target face,  $g_{b1...n}$ , by solving  $3m$  linear  
14 least squares systems of the following form:

$$15 \quad a_j \cdot g_a = g_b[j], i = 1 \dots n,$$

16 wherein said computing comprises using only a subset of points for  
17 each  $g_{aj}$ ; and

18 applying the transformation function to the first set of expressions to  
19 provide a synthetic set of expressions.

20  
21 **53. (PREVIOUSLY PRESENTED)** The method of claim 52, wherein  
22 said using comprises using only points that share edges with a standard sample  
23 point under consideration.  
24  
25

1       **54. (PREVIOUSLY PRESENTED)** A facial expression transformation  
2 method comprising:

3       defining a code book containing data defining a first set of facial  
4 expressions of a first person;

5       providing data defining a second set of facial expressions, the second set of  
6 facial expressions providing a training set of expressions of a second person who  
7 is different from the first person;

8       deriving a transformation function from the training set of expressions and  
9 corresponding expressions from the first set of expressions, wherein the deriving  
10 of the transformation function comprises:

11       representing each expression as a  $3m$ -vector that contains  $x$ ,  $y$ ,  $z$   
12 displacements at  $m$  standard sample positions; and

13       computing a set of linear predictors  $a_j$ , one for each coordinate of  $g_a$ ,  
14 given a set of  $n$  expression vectors for a face to be transformed,  $g_{a1...n}$ , and a  
15 corresponding set of vectors for a target face,  $g_{b1...n}$ , by solving  $3m$  linear  
16 least squares systems of the following form:

$$a_j \cdot g_a = g_b[j], i = 1...n;$$

17       controlling the spread of singular values when computing a  
18 pseudoinverse to solve for the  $a_j$ ; and

19       applying the transformation function to the first set of expressions to  
20 provide a synthetic set of expressions.  
21

22  
23       **55. (PREVIOUSLY PRESENTED)** The method of claim 54, wherein  
24 said controlling the spread comprises zeroing out all singular values less than  $\alpha\sigma_1$ ,  
25 where  $\sigma_1$  is the largest singular value of the matrix.

1  
2       **56. (PREVIOUSLY PRESENTED)** A facial expression transformation  
3 method comprising:

4       defining a code book containing data defining a first set of facial  
5 expressions of a first person;

6       providing data defining a second set of facial expressions, the second set of  
7 facial expressions providing a training set of expressions of a second person who  
8 is different from the first person, wherein said providing data defining a second set  
9 of facial expressions comprises:

10       illuminating the second person's face with illumination, said  
11 illuminating comprising:

12       using multiple light sources, one of which projecting a pattern on the  
13 second person's face from which the structure data can be ascertained;

14       at least one of the light sources comprising an infrared light source;

15       at least one of the light sources being polarized; and

16       contemporaneously capturing structure data describing the face's  
17 structure and reflectance data describing reflectance properties of the face  
18 from the illumination, said capturing comprising using a camera having a  
19 polarizer that suppresses specularly-reflected light so that diffuse  
20 component reflection data is captured;

21       deriving a transformation function from the training set of expressions and  
22 corresponding expressions from the first set of expressions; and

23       applying the transformation function to the first set of expressions to  
24 provide a synthetic set of expressions.  
25

1       **57. (PREVIOUSLY PRESENTED)** A facial expression transformation  
2 method comprising:

3       defining a code book containing data defining a first set of facial  
4 expressions of a first person;

5       providing data defining a second set of facial expressions, the second set of  
6 facial expressions providing a training set of expressions of a second person who  
7 is different from the first person, wherein said providing data defining a second set  
8 of facial expressions comprises:

9           illuminating the second person's face with a first polarized light  
10 source that is selected so that specularly-suppressed reflective properties of  
11 the face can be ascertained;

12          illuminating the second person's face with a second structured light  
13 source that projects a pattern onto the face, while simultaneously  
14 illuminating the face with the first polarized light source; and

15          capturing both specularly-suppressed reflection data and structure  
16 data from the simultaneous illumination;

17          deriving a transformation function from the training set of expressions and  
18 corresponding expressions from the first set of expressions; and

19          applying the transformation function to the first set of expressions to  
20 provide a synthetic set of expressions.

21  
22       **58. (PREVIOUSLY PRESENTED)** The method of claim 57, wherein  
23 the light sources provide light at different frequencies.  
24  
25

1           **59. (PREVIOUSLY PRESENTED)** The method of claim 57, wherein  
2 the light sources provide infrared light.

3  
4           **60. (PREVIOUSLY PRESENTED)** The method of claim 57, further  
5 comprising processing the captured data to provide both (a) data that describes  
6 dimensional aspects of the face and (b) data that describes diffuse reflective  
7 properties of the face.

8  
9           **61. (PREVIOUSLY PRESENTED)** A facial expression transformation  
10 method comprising:

11           defining a code book containing data defining a first set of facial  
12 expressions of a first person;

13           providing data defining a second set of facial expressions, the second set of  
14 facial expressions providing a training set of expressions of a second person who  
15 is different from the first person, wherein said providing data defining a second set  
16 of facial expressions comprises:

17           illuminating the second person's face with multiple different light  
18 sources;

19           measuring range map data from said illuminating;

20           measuring image data from said illuminating;

21           deriving a 3-dimensional surface from the range map data;

22           computing surface normals to the 3-dimensional surface; and

23           processing the surface normals and the image data to derive an  
24 albedo map;

1        deriving a transformation function from the training set of expressions and  
2        corresponding expressions from the first set of expressions; and  
3        applying the transformation function to the first set of expressions to  
4        provide a synthetic set of expressions.

5  
6        **62. (PREVIOUSLY PRESENTED)** The method of claim 61, wherein  
7        at least one of the light sources is polarized.

8  
9        **63. (PREVIOUSLY PRESENTED)** The method of claim 61, wherein  
10       all of the light sources are polarized.